Are Male House Wrens (*Troglodytes aedon*) Open-ended or Closed-ended Learners?

Research Thesis

Presented in partial fulfillment of the requirements for graduation with Research Distinction in Biology in the Undergraduate Colleges of The Ohio State University

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The Ohio State University June 2016

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Abstract

Songbirds are typically classified as either ‘open-ended’ learners or ‘closed-ended’ learners. Open-ended learners can expand their vocalizations even as mature adults; whereas, closed-ended learners generally develop songs within their first year with few changes after that. Knowing whether House Wrens are open-ended learners or closed-ended learners is important because song may affect a male’s reproductive success through indicating the quality of the signaler. The purpose of this study was to determine if male House Wren (*Troglodytes aedon*) songs change with age or experience. If House Wrens are ‘closed-ended’ learners, they should have consistent song between first and second nests within each year and between first nests in different years. If House Wrens are ‘open-ended’ learners, they should show consistent changes in song length, rate and frequency range. Male House Wren song was recorded during the incubation stage with a microphone attached to the pole that holds the nest box. Song rate (#songs/minute), duration (length of each song), and frequency were analyzed from the recordings. We found that there was an increase in song rate between years, but this was not enough evidence to say males House Wrens are open-ended learners due to possible familiarity with the study site allowing them to spend less time foraging and more time singing. Future research may suggest that human noise pollution, climate or weather changes, or experience could possibly affect their singing.

Introduction

Communication occurs when an individual shares meaningful information with another member of the same species (Kimura 1993). Communication materializes for different reasons. For example, birds sing to defend their territory, attract mates, and to communicate with mates (Johnson & Kermott 1991; Kroodsma 2005). Songbirds are often used to study animal communication because they have a sensitive learning period within the first few weeks of hatching where vocal learning transpires (Catchpole & Slater 1995; Hultsch & Todt 2004; Kroodsma 2004).

Vocal learning occurs through imitation, improvisation, or by listening to auditory feedback (Liu & Nottebohm 2010). Songbirds generally fall into two categories: 'Open-ended' learners and 'closed-ended' learners (Nottebohm & Nottebohm 1978; Eens *et al.* 1992; Gil *et al.* 2001; Mamede & Mota 2012). Open-ended learners can expand their vocalizations even as mature adults, whereas closed-ended learners generally develop songs within their first year with few changes after that (Beecher & Brenowitz 2005). Northern Mockingbirds (*Mimus polyglottos*) and European Starlings (*Sturnus vulgaris*) are examples of open-ended learners. These birds learn new vocalizations throughout their life span (Beecher & Brenowitz 2005). Examples of closed-ended learners are Zebra Finches (*Taeniopygia guttata*) and Bengalese Finches (*Lonchura striata domestica*). These finches learn a song within their first year of life and will continue to sing the same song throughout the continuation of their life (Beecher & Brenowitz 2005). The dichotomy between open-ended learners and close-ended learners is blurred in some species. For example, Ota and Soma (2014) found that a closed-ended learner, the Java sparrow (*Lonchura oryzivora)*, had an increased frequency bandwidth and peak frequency of song notes with older age. Ota and Soma (2014) also found that song length increased a year after song

crystallization. Therefore, additional tests of close-ended learners are required to determine whether they have any capacity for learning after the first year of life.

A male's ability to learn song may affect his reproductive success through female choice and male-male competition. Song quality, as measured by syllable repertoire size and amplitude, may reflect male quality and affect female mate choice and the male's ability to defend territory against other males (Buchanan& Catchpole 1997; Brumm & Ritschard 2011). Song complexity can also be measured by repertoire size, or the number of distinctive vocal components that include song types, syllables used, and repetition (Garamszegi *et al.* 2012). If a male has a larger repertoire, then his chances of finding a mate may increase more than if he repeated a single song type (Kroodsma 1976; Platt & Ficken 1987).

The purpose of this study was to determine if male House Wren songs change with age or experience, as would be predicted if song characteristics reflected a male's ability to learn song. If House Wrens are 'closed-ended' learners, they should have consistent songs between first and second nests within each year and between first nests in different years. If House Wrens are 'open-ended' learners, they should show consistent changes in song length, rate and frequency range. To test these hypotheses, we recorded male song during the incubation stage, compared his vocalizations during his first and second nests within a year, and during his first nests between years.

Methods

Study Species:

House Wrens were chosen for this study because they because they utilize artificial nest boxes which allows for large sample sizes. This also made it easy to locate males' first and

second nesting attempts within and between years. At least 38% of male House Wrens return to a previous breeding area each year (Drilling & Thompson 1988); Male's songs can be complex and are composed of fast, high pitched notes that fall towards the end (Johnson 1998). Males can sing anywhere from 1.5 seconds to 2.5 seconds at a frequency ranging from 1.5 to 8.0 kHz (Johnson 1998). Males have an introductory section and a terminal section in their song. They introduce their songs at a low-amplitude with an array of complex syllables that are considered "chattery" (Platt & Ficken 1987; Johnson 1998). During the terminal section, they produce louder, "bubbly" notes and repeat up to six syllables, 1-10 times (Platt & Ficken 1987; Johnson 1998). Also, male House Wrens sing an average of 19 ± 6 songs per 15-minute recording (Schafer 2012), allowing for large song samples from individual males.

Study Sites:

Research was conducted from May to August 2012-2014 in Lima, Ohio USA. Nest boxes were established in three habitats: a wooded habitat and park on The Ohio State University at Lima campus (40.7363927° N, 84.0266254° W; 40.736071°N, 84.029864°W, respectively), and Hawthorne Hills Golf Course (40.752005°N, 84.036931°W). In all habitats, nest boxes were placed 30m apart along the edge of the forest or fence line, adjacent to natural or mowed grass. The nest boxes that were used for this experiment were 10.1cm in width, 14.0cm in length, and 20.3cm in depth. The hole on the front of the box was 2.9cm in diameter. This hole size was small enough to allow a House Wren access to the box and keep most other bird species out. A sliding, rectangular piece of wood was located on the front of the nest box to trap adults for banding purposes. Each adult was given a unique combination of colored leg bands so we can track individuals within and between seasons.

Nesting Observations:

Nest boxes were checked two times each week unless laying or hatching was to be expected. Then, the nests were checked daily. Laying was expected when a nest cup was formed, which is bowl shaped and is lined with grass, phloem of a tree, feathers, and hair (Johnson 1998). Ten days after the last egg was laid, we checked nest boxes daily for hatching because hatching usually commences after 12-13 days of incubation had passed (Bowers *et al.* 2012).

Song Recording and Analysis:

Recordings occurred during the incubation stage because the males consistently sang near the box when the female was incubating. Thirty uninterrupted minutes of recording were made during the hours of 0600 and 1200 using an Audio Technica shotgun microphone and a Marantz PMD-660 digital recorder. The microphone was pointed upward and strapped vertically to the pole that holds the nest box. The date, box number, and start time was recorded. To avoid researcher interference, researchers stayed at least 30m away during the recordings.

Program Signal (Version 4.04.29, Cambridge Electronic Devices 2008, Cambridge, UK) was used to measure song rate, song length, mean frequency, and maximum frequency for a fifteen-minute period starting with the first song recorded. We compared first and second nests within a season and first nests between successive years. If a male was present in multiple years, his vocalizations from one year was selected at random for the year comparison. If a male was present for three years, his vocalizations from only two successive years were included in the year comparison. A matched pairs analysis (paired *t*-test) was used to compare the means of two vocalization recordings of a given male to account for variation among males. Analyses were conducted in JMP (Ver. 11.0, SAS Institute Inc., Cary, NC). Means are presented with their SE.

In some cases, it was not possible to measure every variable for every individual, so sample sizes might vary among analyses.

Results

We were able to obtain recordings from 19 males between first and second nests within a year. Between years, we were able to obtain recordings from 14 males. We analyzed 1640 individual songs from 59 recordings. All songs consisted of chattery notes followed by bubbly notes, such as the song depicted in Figure 1. Of the 59 recordings analyzed, there was an average of 28.3 ± 2.7 songs per 15-minute recording. The average length of wren song was 1.71 ± 0.03 s. The mean minimum frequency of wren song was 3122.5 ± 59.9 Hz. The mean dominant frequency of wren song was 3998.7 ± 56.4 Hz. The average maximum frequency was 5688.1 ± 91.0 Hz.

We found that there was an increase in song rate between years (Table 1, Figure 2), but not within years (Table 1, Figure 3). Song length and frequency did not change between or within years (Table 1).

Discussion

Because length and frequency did not change both within and between years, House Wrens are probably closed-ended learners. Frequency may be important in species recognition, so natural selection may favor song consistency. Similar results were seen by Gil and Slater (2000), who looked at the singing patterns of the Willow Warbler and found that new elements of bird song may appear, but the core repertoire does not change between songs. They found that the warbler's introduction was invariably similar for each bird, thus allowing a quick assessment by the receiver (Gil & Slater 2000).

Song rate increased between years, but we do not believe this is due to learning. Song rate may increase due to familiarity with the study area allowing birds to spend less time foraging and more time singing. Similar results were obtained by Lanctot *et al*. (2000), who found high song rates correlated with experienced male Western Sandpipers (*Calidris mauri*) returning to previous breeding sites. They suggested that reasons for these high song rates is due to early arrival in the season to compete with other high quality males and to obtain territory.

Our results that male house wren song was consistent within and between years are contrary to Cramer's (2013) findings which found that older male House Wrens had a higher trill rate consistency than younger males. Unlike our study, her study suggested there may be some song learning beyond their first year of life in this species. Rivera-Guitierrez *et al*. (2011) studied the Great Tit (*Parus major*) and also found that song consistency increased with age. Both studies proposed that information on experience or dominance may be provided through song consistency. For future studies, we could look at song consistency and repertoire size to resolve discrepancies in how song may change with age.

House Wrens may not be indicating age through their vocalizations, or age may not be an important factor in House Wrens' reproductive success. Eckerle and Thompson (2006) studied the reproductive behavior of House Wrens and they argued that females select males based on nest-site quality, which includes characteristics of the nest-site, and the quantity of nest-sites on a male's territory. The more territory a male obtains, the better their chances are at reproducing (Eckerle & Thompson 2006). Additionally, Johnson and Searcy (1995) examined whether or not the song of male House Wrens can be used as a function to attract mates. They played a male house wren song from a speaker near an empty nest box. They also set up a silent control box. Johnson and Searcy (1995) found that more female House Wrens visited the box near the

projected pseudo male songs and concluded that the song of male House Wrens is a function to attract mates for breeding. Johnson and Kermott (1991) found multiple functions of song in male House Wrens. They concurred that song functions in mate attraction. They also observed males directing song at other males and intruders if they were in the male's territory (Johnson & Kermott 1991). They conjectured that song could function as a way to inform a mate that no predators were nearby (Johnson & Kermott 1991).

A confounding factor that may have affected our results could be human noise pollution. Open-ended learners would probably have an easier time adjusting their frequency to the human noise pollution, but closed-ended learners would probably have a harder time if their songs are consistent. Our recordings were often interrupted by train whistles, lawn mowers and aircraft noise. Human noise pollution could have also caused decreased song output during the time the recordings were obtained. Cartwright *et al*. (2013) suggests that human noise pollution could have an effect on songbirds' vocalizations. They studied Red-winged Blackbirds (*Agelaius phoeniceus*) in urban and rural areas and found that in rural sites, singing was higher in the morning and evening, while in urban areas, singing decreased in the morning and evenings to avoid loud rush hour periods and increased song output in the middle of the day. They found that urban noise impacted communication structure and daily pattern of song production. A study conducted by Redondo *et al*. (2013) found that urban noise influences vocalization structure in the House Wren. They found that wrens in urban areas increased trill rate and reduced frequency bandwidth (Redondo *et al.* 2013). By reducing bandwidth, signal tonality increases and transmits better in a noisy environment (Lohr *et al*. 2003; Hanna *et al.* 2011).

For future studies, it would be interesting to see how the climate or weather affects their singing. Snell-Rood (2011) studied North American wood warblers (*Parulidae*) and proposed

that climate affects sound absorption. She found that it affected bandwidth and frequency and that signalers may have to evolve a different signal structure or receptive structure over time. Again, we would predict that open-ended learners would demonstrate shifts in bandwidth or frequency at a higher rate than close-ended learners.

In summary, communication helps species share information with each other, from defending territory, attracting mates, to communicating with mates. Songbirds obtain communication skills through vocal learning. Our results suggest that House Wrens are closed-ended learners because song length and frequency did not change between first and second nests within a year nor between first nests in different years. Song rate did increase between years, but may indicate familiarity with the habitat and not song learning.

Acknowledgements

We thank Hawthorne Hills Golf Course for access to the property, and the Borror Lab of Bioacoustics for lending us the song recording equipment. We also want to thank Alex Crawford, Alex Davis, and Jackie Smith for assistance in the field. Funding was obtained from Undergraduate Education Summer Research Fellowship from The Ohio State University. This research was conducted under the following permits: IACUC Protocol 2013A00000062 at The Ohio State University, Federal Bird Banding Permit #23569, Ohio Banding Permit #16-13.

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Table 1: The differences between song rate, length, and frequency between and within years from a matched pairs analysis of house wren song.

		t	N	P
Between Years				
	Song Rate	1.82	14	0.046
	Song Length	1.19	14	0.13
	Minimum Frequency	0.25	14	0.40
	Maximum Frequency	-0.39	14	0.65
	Dominant Frequency	-0.64	14	0.73
Within Years				
	Song Rate	0.47	19	0.32
	Song Length	-0.48	19	0.68
	Minimum Frequency	-0.09	19	0.53
	Maximum Frequency	-0.23	19	0.59
	Dominant Frequency	-0.16	19	0.56

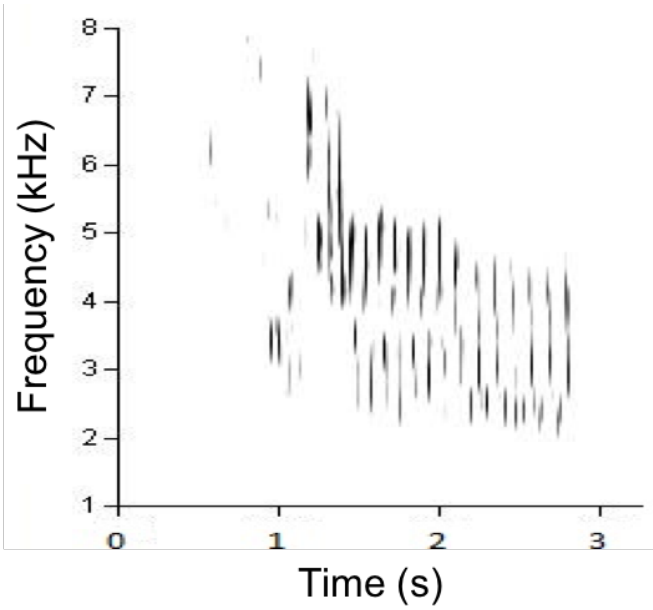

Figure 1: Characteristic House Wren sonogram with a low frequency chatter followed by higher frequency and bubbly notes recorded in northwestern Ohio.

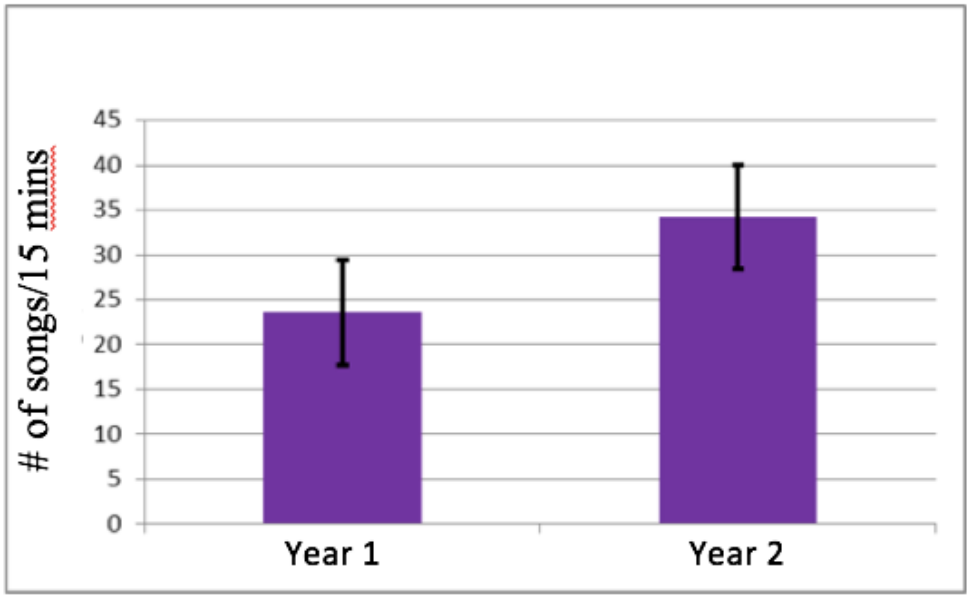

Figure 2: Song rate of House Wrens increased between years in northwestern Ohio. Means are presented with their standard error.

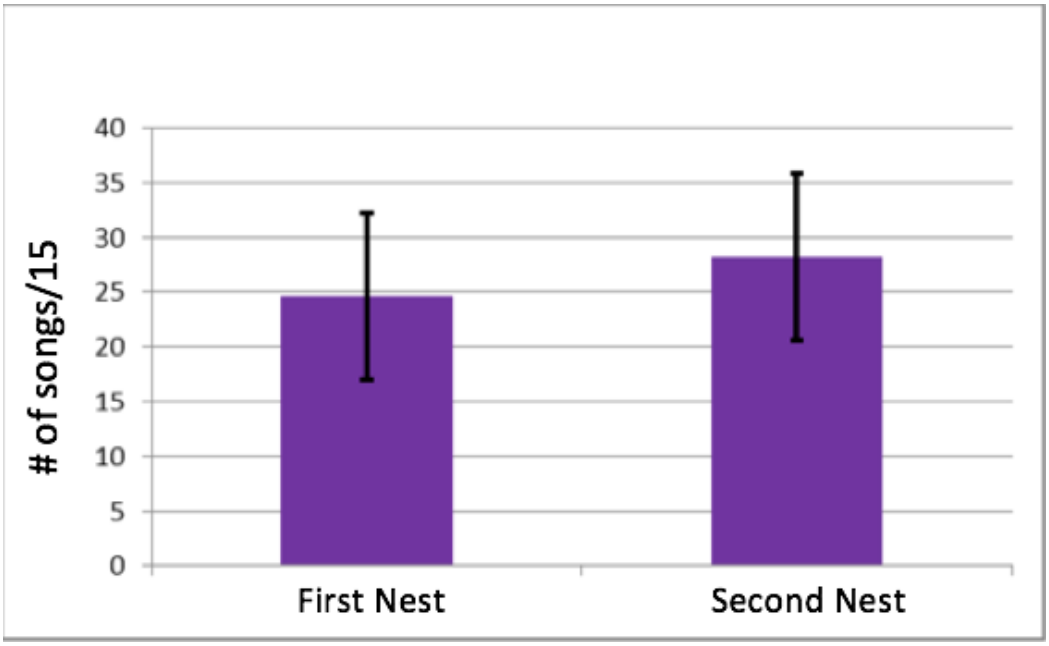

Figure 3: Song rate of House Wrens were similar between first nests and second nests within years in Lima, OH. Means are presented with their standard error.